Climate prediction for climate services: the SPECS project

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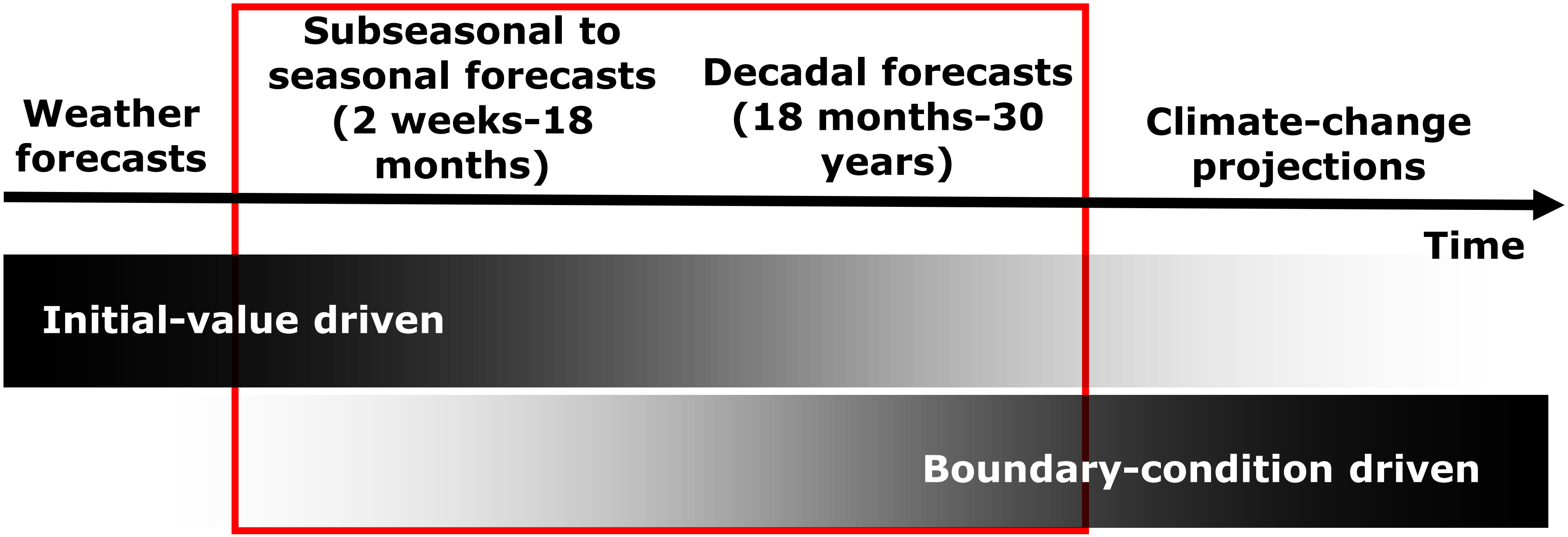
SEVENTH FRAMEWORK PROGRAMME

SPECS
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

Prediction on climate time scales

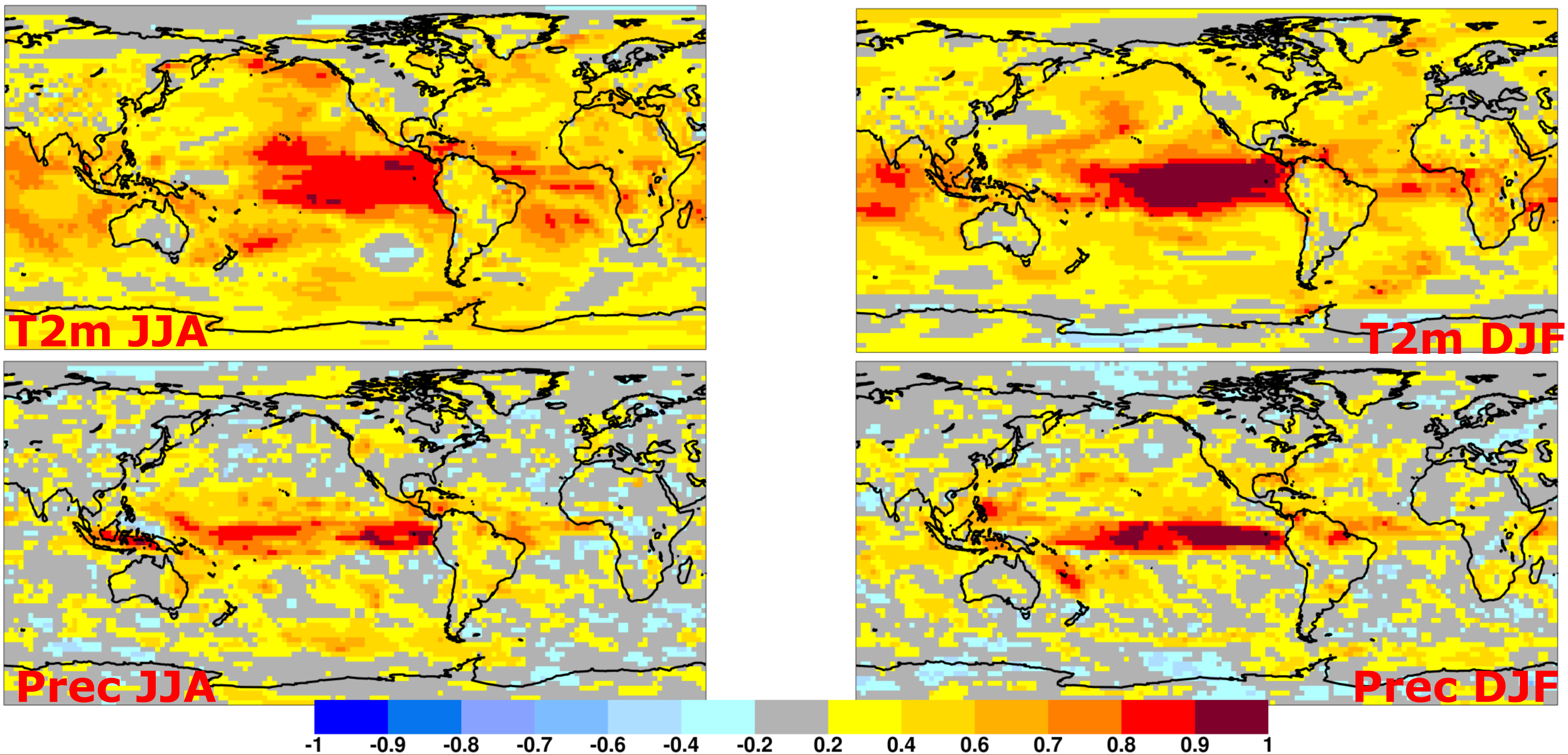
Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialization and systematic comparison with a simultaneous reference.



Adapted from Meehl et al. (2009)

Typical seasonal forecast skill

Correlation of the ensemble mean for the ENSEMBLES multi-model (45 members) wrt ERA40-ERAInt (T2m over 1960-2005) and GPCP (precip over 1980-2005) with 1-month lead.



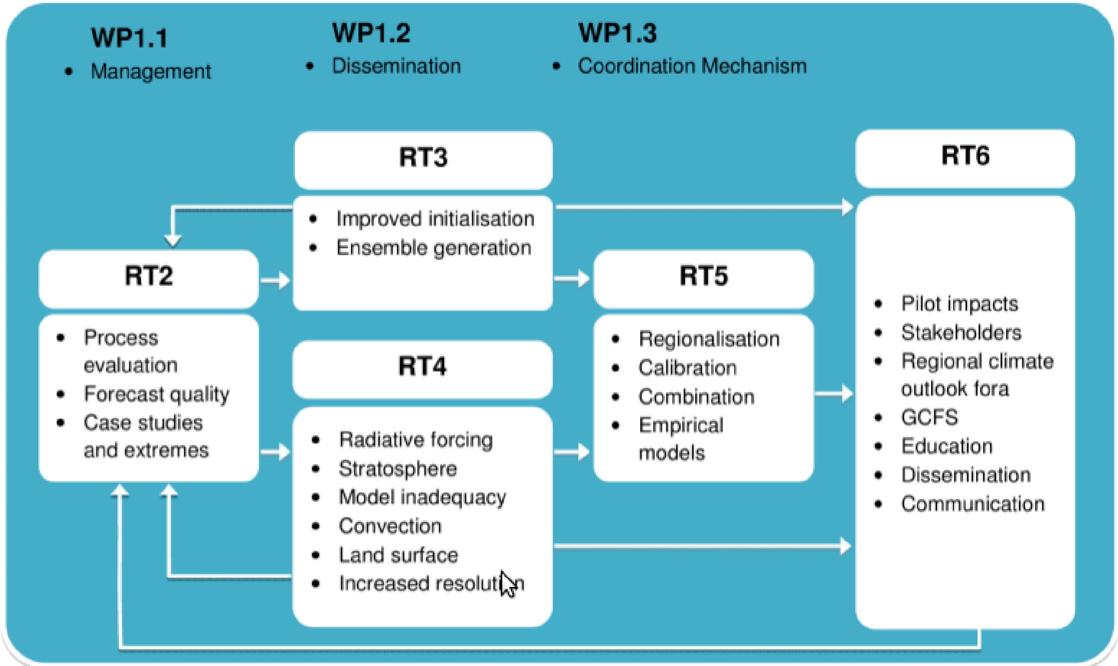
Some open fronts

- Work on initialisation: initial conditions for all components (including better ocean), better ensemble generation, etc. Link to observational and reanalysis efforts.
- Model improvement: leverage knowledge and resources from modelling at other time scales, drift reduction, better sea ice, projections of volcanic and anthropogenic aerosols, vegetation and land, etc. More efficient codes and adequate computing resources.
- Calibration and combination: empirical prediction (better use of current benchmarks), local knowledge.
- Forecast quality assessment: scores closer to the user, reliability as a main target, process-based verification.
- More sensitivity to the users' needs: going beyond downscaling, better documentation (e.g. use the IPCC language), demonstration of value and outreach.

SPECS FP7, overall strategy

SPECS will deliver *a new generation of European climate forecast systems*, *including initialised Earth System Models (ESMs) and efficient regionalisation tools to produce quasi-operational and actionable local climate information over land at seasonal-to-decadal time scales with improved forecast quality and a focus on extreme climate events, and provide an enhanced communication protocol and services to satisfy the climate information needs of a wide range of public and private stakeholders*.

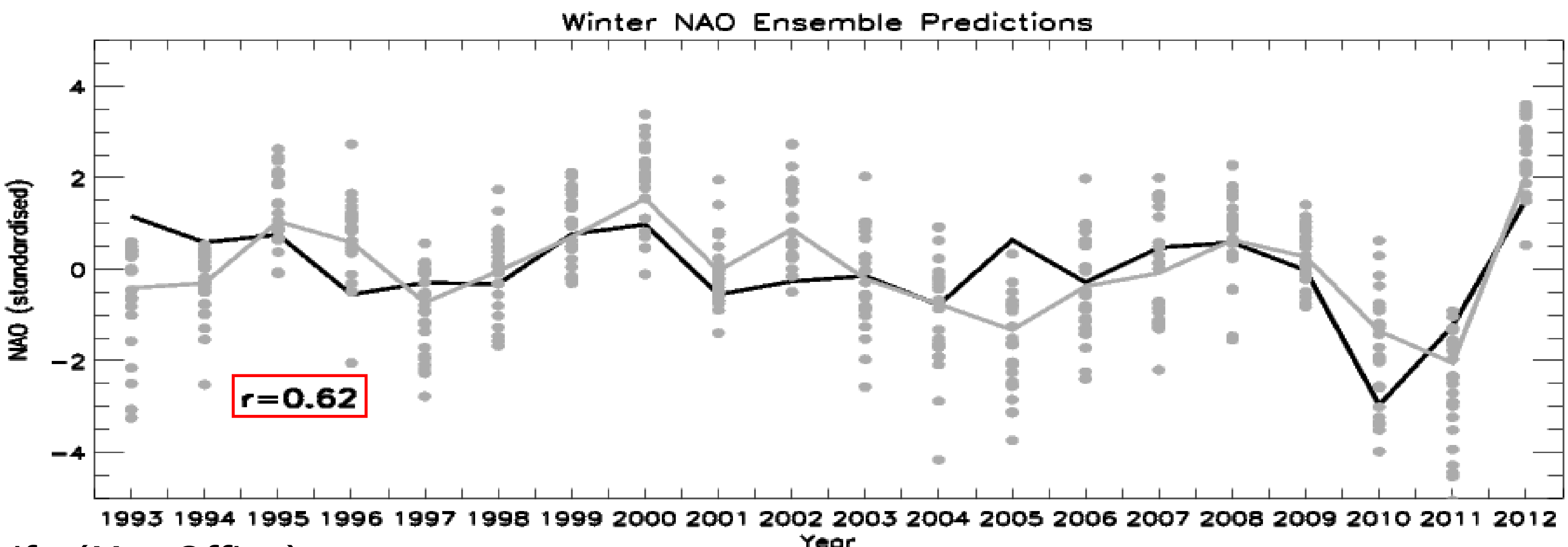
Forecast System	Project Partners
CNRM-CM5	CNRM, CERFACS
EC-Earth	KNMI, SMHI, IC3, ENEA
IFS/NEMO	ECMWF, UOXF
IPSL-CM5	CNRS
MPI-ESM	MPG, UniHH
UM	UKMET



WP1.1: Management
WP1.2: Dissemination
WP1.3: Coordination across EUPORIAS, NACLIM & SPECS
RT2: Evaluation of current s2d forecast systems
RT3: Forecast strategies
RT4: Improved systems
RT5: Calibrated predictions at the local scale

Predicting NA atmospheric circulation

DJF NAO Met Office operational seasonal forecasts with HadGEM3H N216L85O(0.25) with initial conditions from operational atmospheric analyses and NEMOVAR, 24 members, start date around the 1st of November (lagged method). Winter NAO correlation significant at the 98% confidence level.

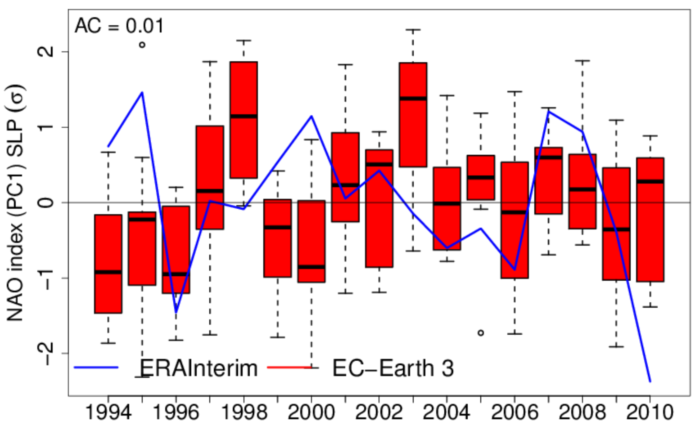


A. Scaife (Met Office)

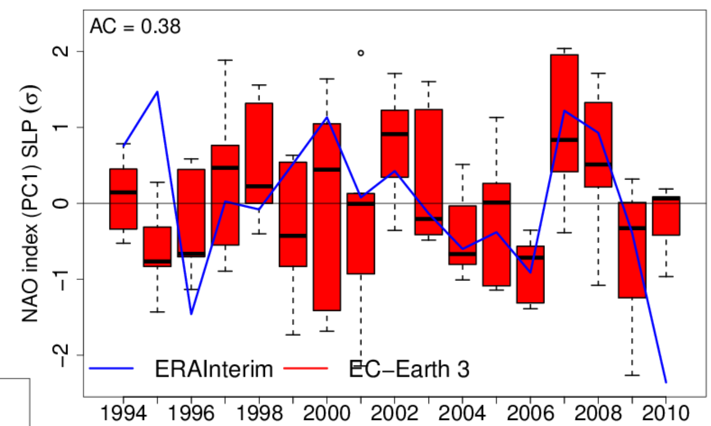
Predicting NA atmospheric circulation

Predictions of DJF NAO with **EC-Earth3 low and high resolution** and ECMWF S4 started in November over 1993-2009 with ERA-Interim and GLORYS initial conditions and ten-member ensembles. Correlation of the ensemble mean on top left.

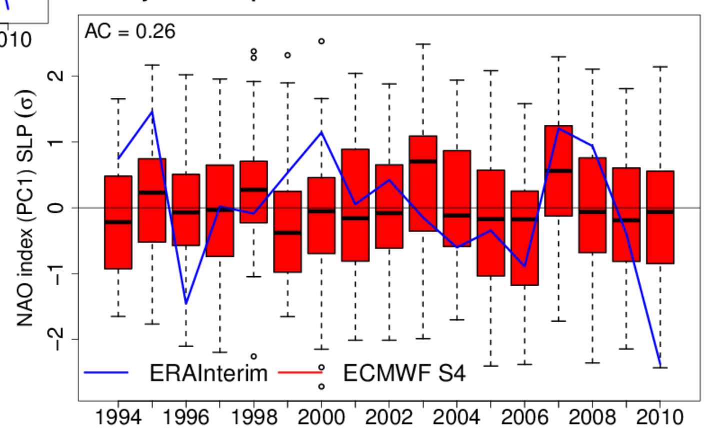
EC-Earth3 T255/ORCA1



EC-Earth3 T511/ORCA025



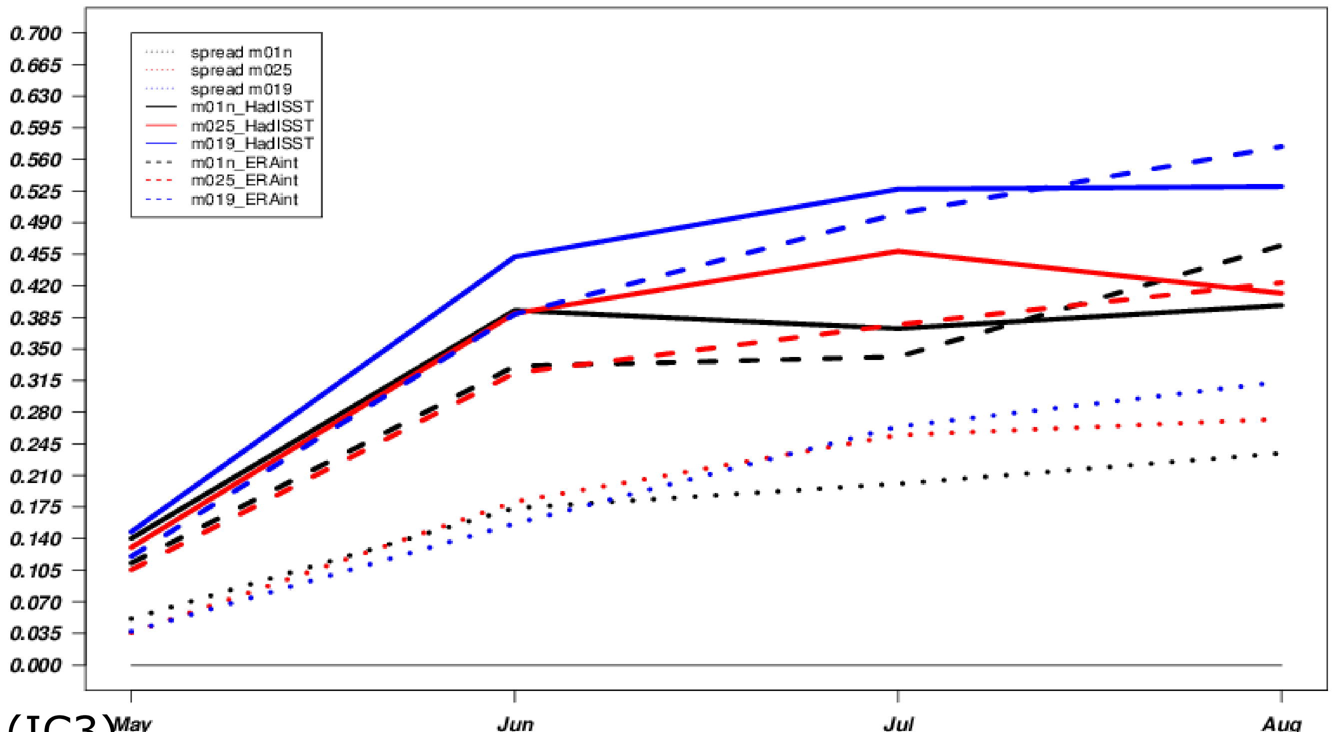
ECMWF S4



Batté et al. (2014)

Increase in resolution: ENSO skill

RMSE and spread of Niño3.4 SST (versus HadISST-solid and ERAInt-dashed) from four-month EC-Earth3 simulations: **T255/ORCA1**, **T255/ORCA025** and **T511/ORCA025**. May start dates over 1993-2009 using ERA-Interim and GLORYS initial conditions and ten-member ensembles.

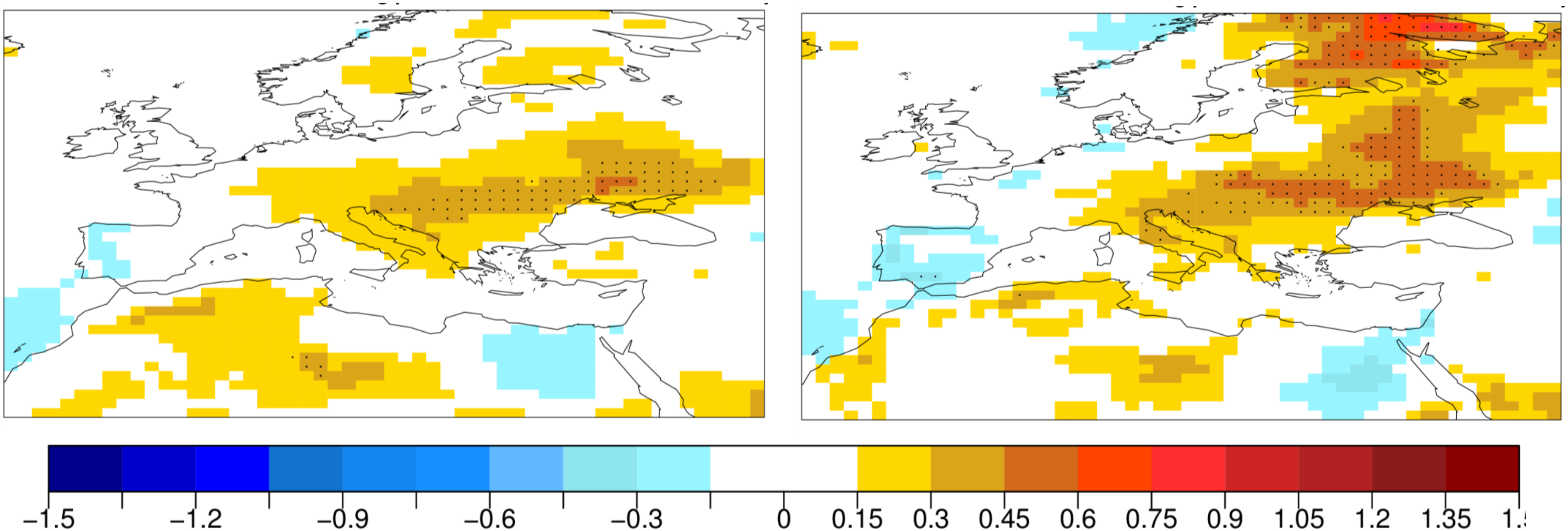


C. Prodhomme (IC3)

Impact of initialisation: Land surface

Difference in the correlation of the ensemble-mean near-surface temperature from two experiments, one using a realistic and another a climatological land-surface initialisation. Results for boreal summer with EC-Earth2.3 hindcasts started every May over 1979-2010 with ERAInt and ORAS4 and a sea-ice reconstruction as initial conditions.

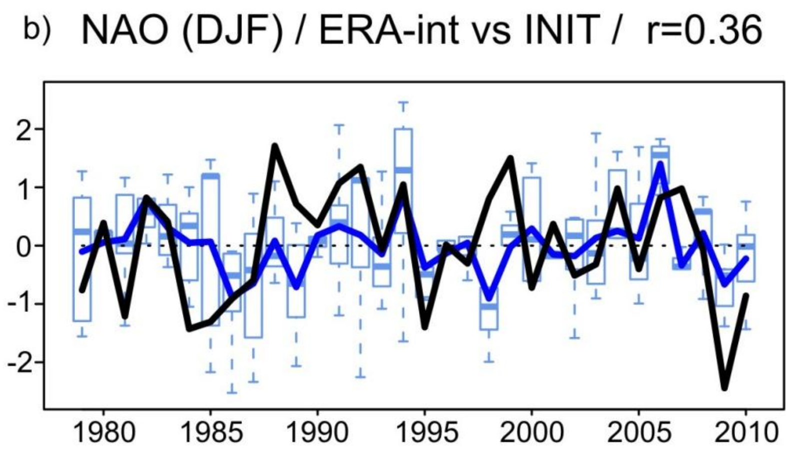
Difference for mean T **Difference for T max**

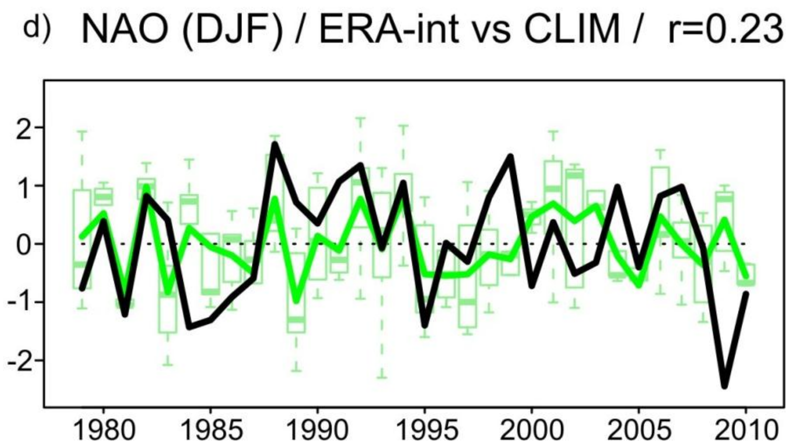


Prodhomme et al. (2014)

Predicting NA atmospheric circulation

Predictions of DJF NAO with EC-Earth2.3 started in November over 1979-2010 with ERAInt and ORAS4 initial conditions. Two sets, one initialised **with realistic (top) and one with climatological (bottom) sea-ice initial conditions**.

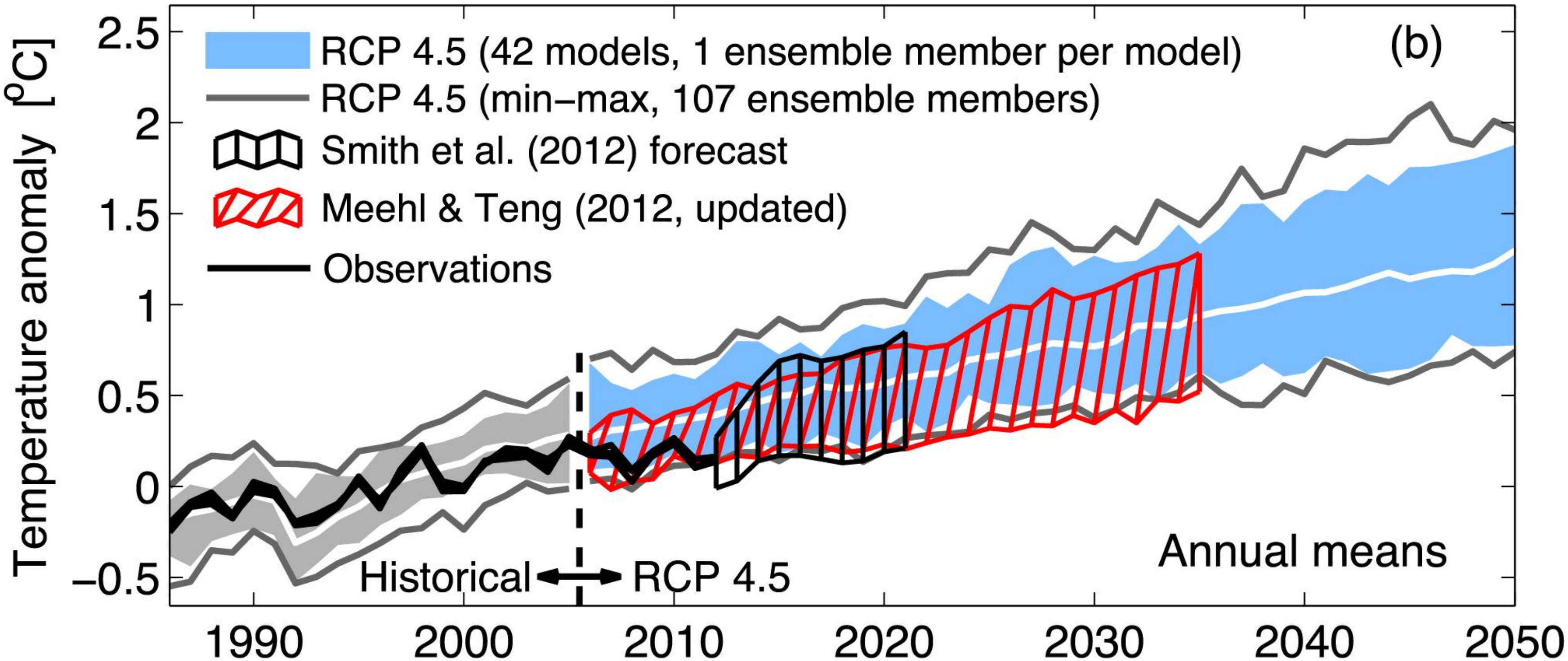




J. García-Serrano (IPSL)

Predictions and projections

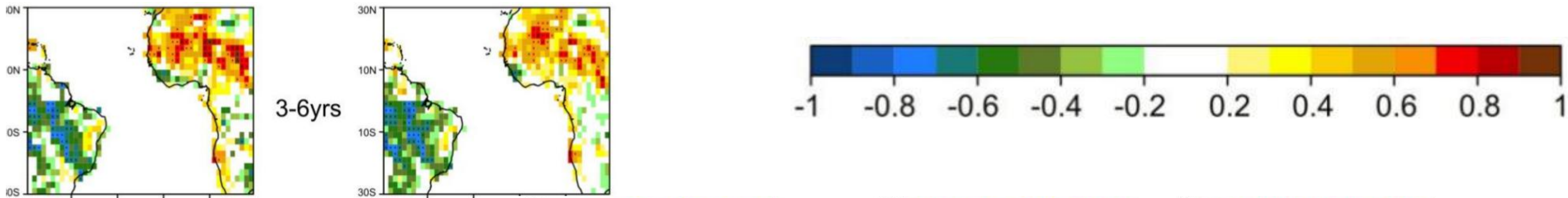
Annual-mean global-mean temperature predictions and projections from CMIP5.

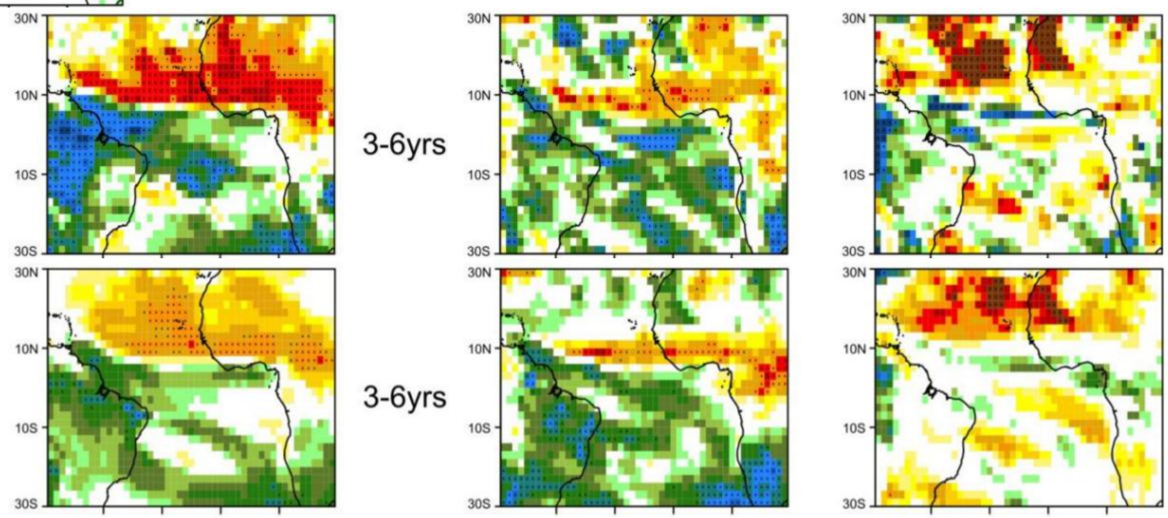


IPCC AR5 WGI (2013)

North Atlantic decadal prediction

(Top) Correlation of the observed AMV index (ERSST as a reference) and the ensemble mean 3-6 year averaged (two year lagged) GPCC precipitation with five-year (left) and one-year (right) intervals. (Centre) Correlation of observed AMV and the 3-6 forecast year prediction from CMIP5 decadal hindcasts with five-year start date frequency from the initialised (left), non-initialised (centre) and the difference (right). (Bottom) Same as central row but for the simulations with one-year start date frequency. Dots for significant correlations with 95% conf. level.





García-Serrano et al. (2014)

Real-time decadal prediction exchange

Figures now available, predictions distributed soon.

http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/long-range/decadal-multimodel

Multi-model decadal forecast exchange

The Met Office coordinates an informal exchange of near-real time decadal predictions. Many institutions around the world are developing decadal prediction capability and this informal exchange is intended to facilitate research and collaboration on the topic.

The contributing prediction systems are a mixture of dynamical and statistical methods. The prediction from each institute is shown below, alongside an average of all the models. When possible, observations for the period of the forecast are also shown. Currently three variables are included: surface air temperature, sea-level pressure and precipitation. These are shown as differences from the 1971-2000 baseline. More diagnostics, including ocean variables are planned for the future. Please use the drop-down menus below to explore the data collected to date.

This work is supported by the European Commission SPECS project.

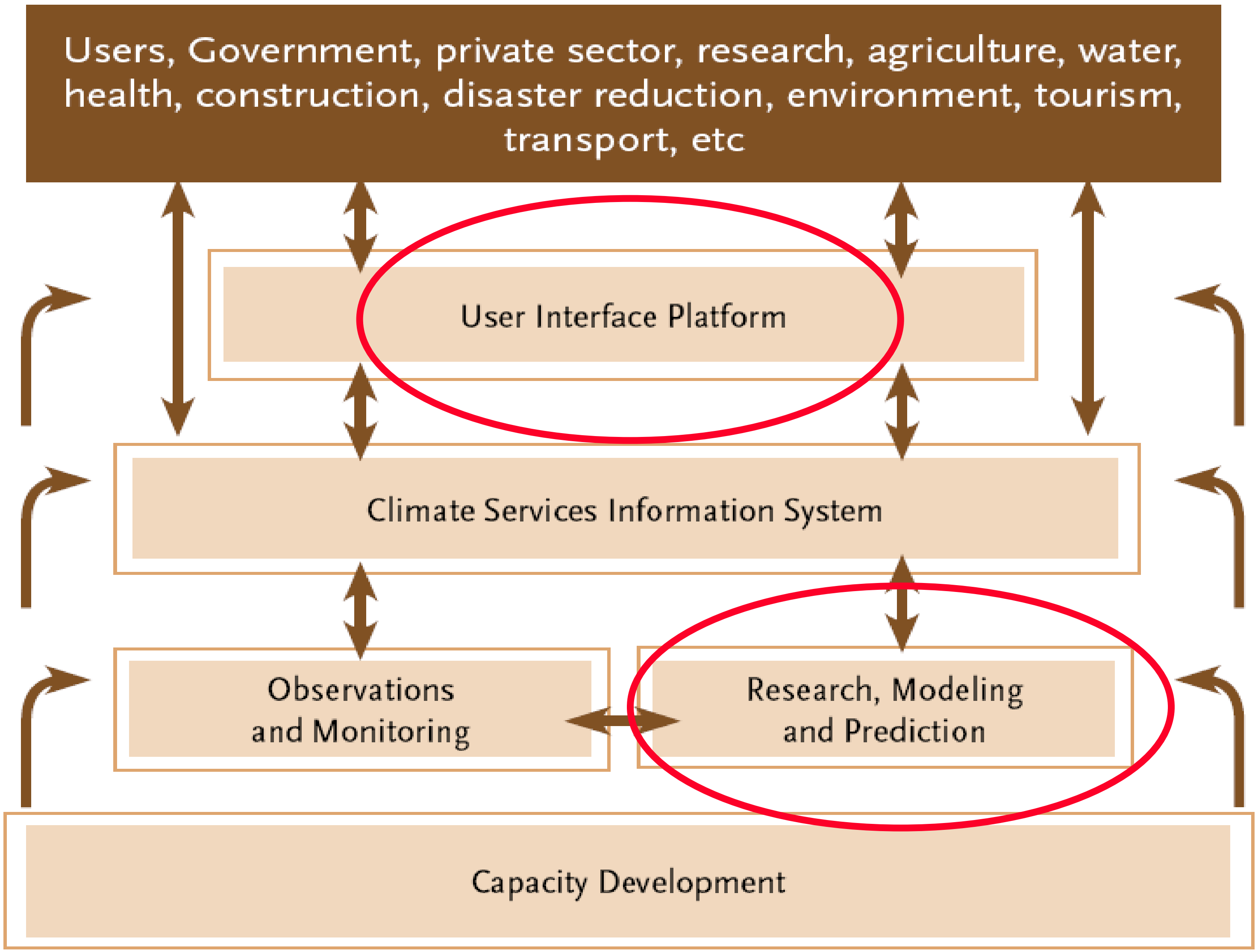
To learn more about decadal forecasts at the Met Office, see our current decadal forecast.

Images last updated 2014-02-20

Issued	Period	Element
2012	year 1	surface air temperature

Decadal forecast exchange 2012 predictions for year 1 surface air temperature

Global framework on climate services

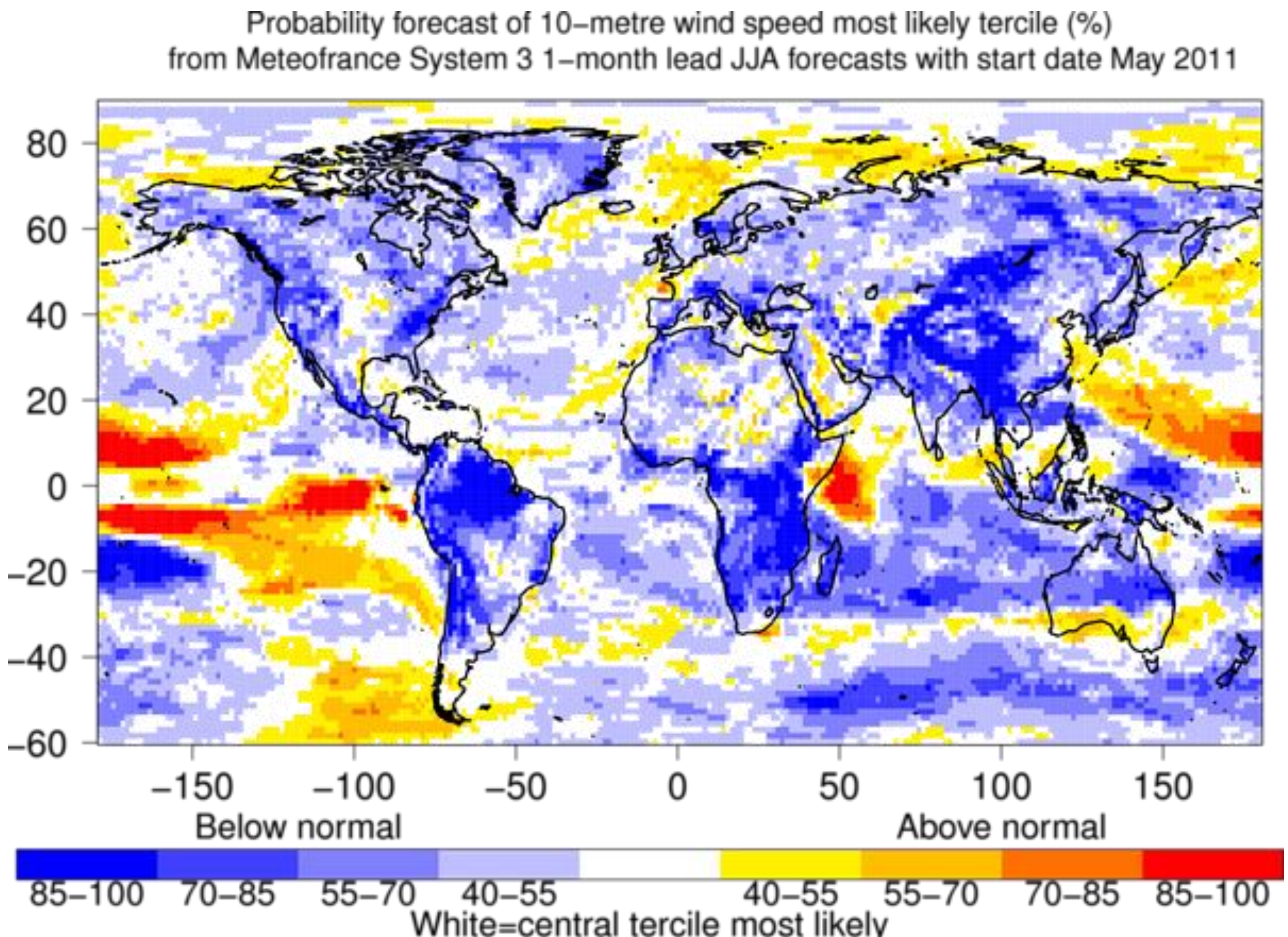


Some of the things still missing

- Understanding of the impact models, and the best way to adapt them to the useful climate information available
- Bias correction
- Calibration and combination
- Downscaling, when necessary
- Documentation (follow the IPCC calibrated language), demonstration of value and outreach
- The EUPORIAS project, working alongside SPECS, is considering solutions to address some of these problems.

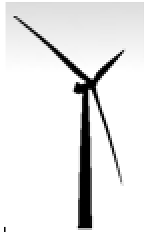
Climate services: wind energy

What climate forecasters traditionally offer



Doblas-Reyes et al. (2013)

Climate services: wind energy



What is actually requested in terms of forecasts:

- Forecasts for locations where the mean is large (wind speed above a threshold), and both variability (something to predict) and skill (something useful to say) are high
- Need energy generated over a period (month, season, etc), with uncertainty estimates, at the wind farm level
- Information for off-shore maintenance (at least 3 weeks lead time)
- Also, energy and consumption in other regions to balance network
- Take into account
  - Management strategies
  - Development plans

Back to the wind energy problem

To satisfy the users' requirements for sub-seasonal to seasonal forecast information:

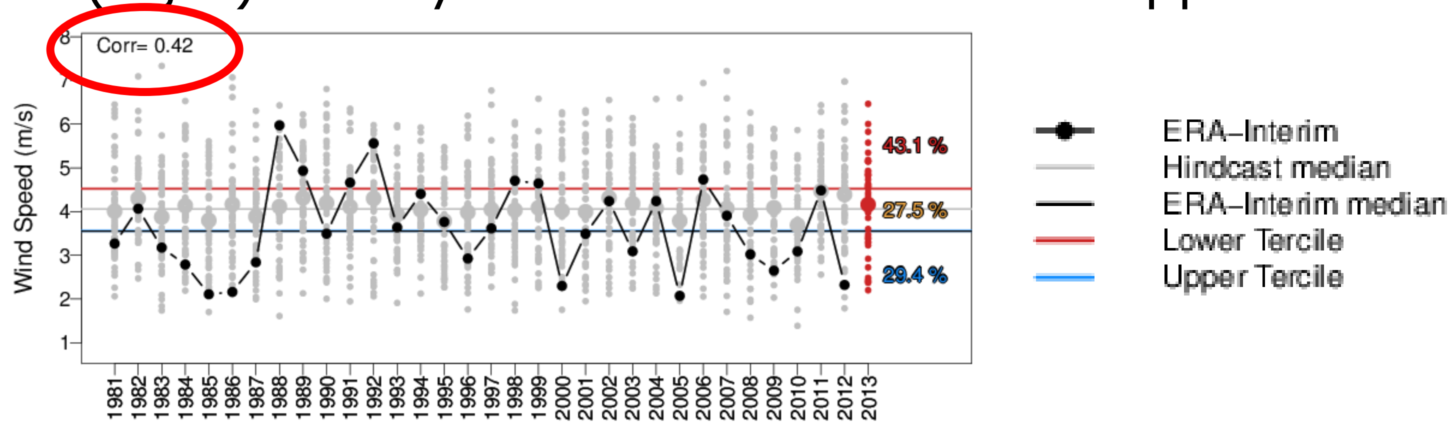
- High-frequency wind forecasts at ~100 metre height
- Bias corrected forecast data, i.e. whose statistical properties mimic those of the data measured at the wind turbine height -> Bias correcting and calibrating high-frequency data is extremely complicated and destroys some of the little skill available

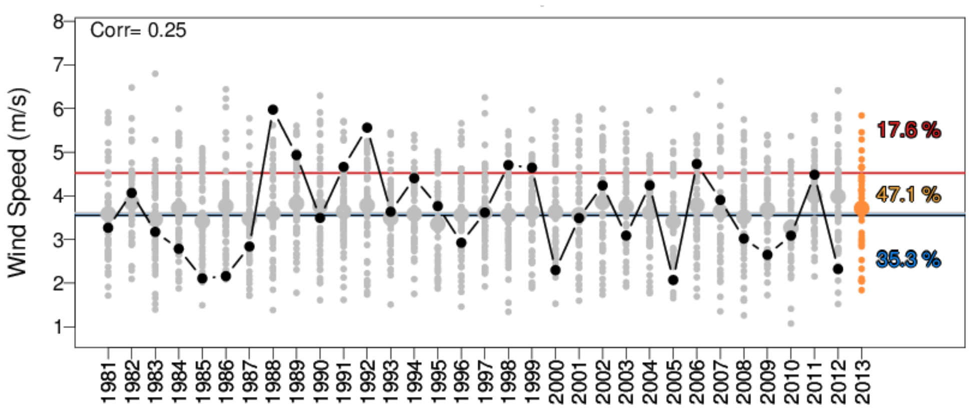
On top of this:

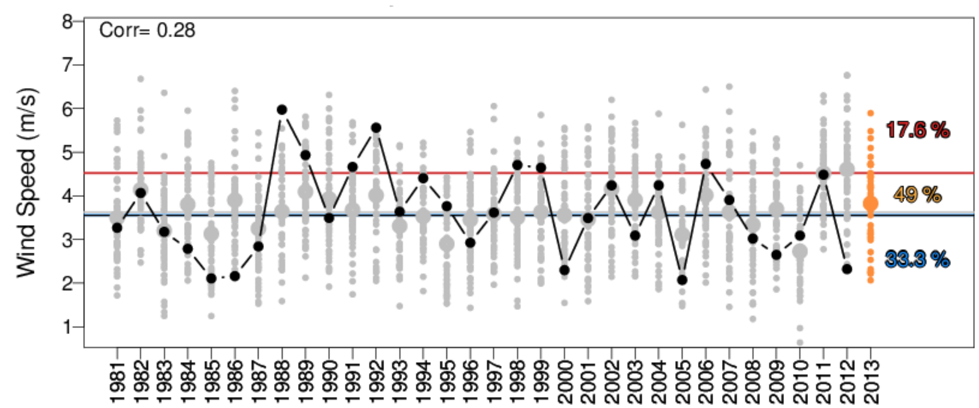
- Local measurements are not long
- They are not even made available

Bias correction and calibration

Bias correction and calibration have different effects. ECMWF S4 predictions of 10 m wind speed over the North Sea for DJF starting in November. Raw output (top), bias corrected (simple scaling, left) and ensemble calibration (right). One-year-out cross-validation applied.



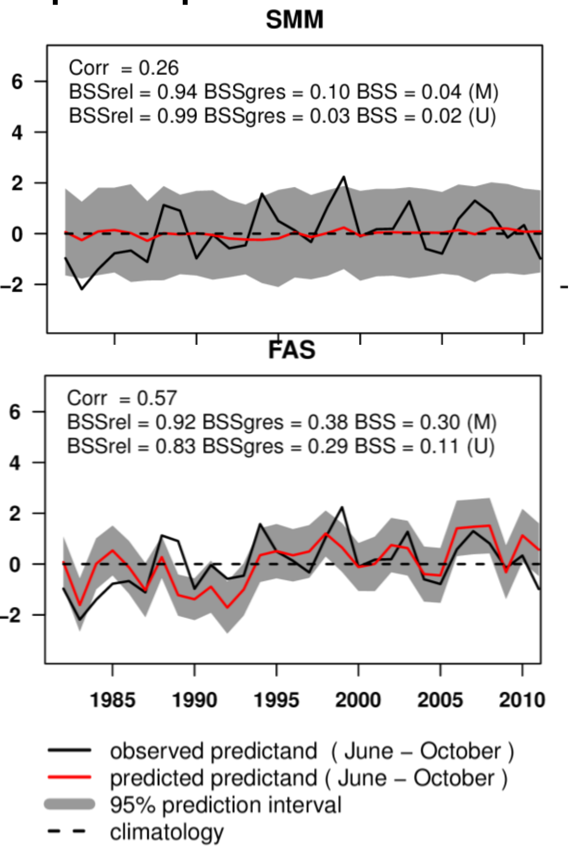


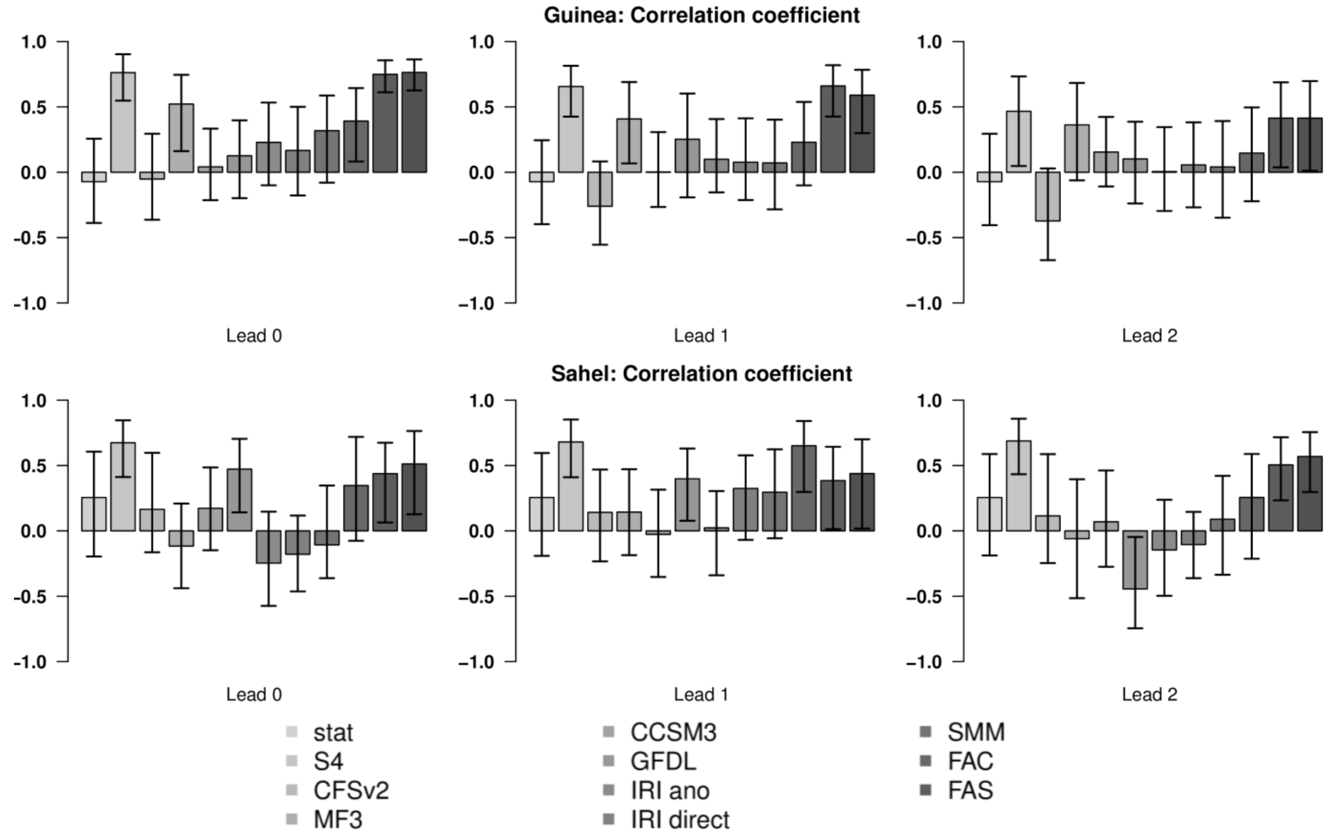


V. Torralba (IC3)

Calibration and combination: WAM

(Left) Multi-model seasonal predictions of Sahel precipitation, including its intraseasonal variability from June to October, started in April. (Right) Correlation of the ensemble mean prediction for Guinean and Sahel precipitation. *Reliability is fundamental for climate services.*





Rodrigues et al. (2014)

Downscaling for seasonal predictions

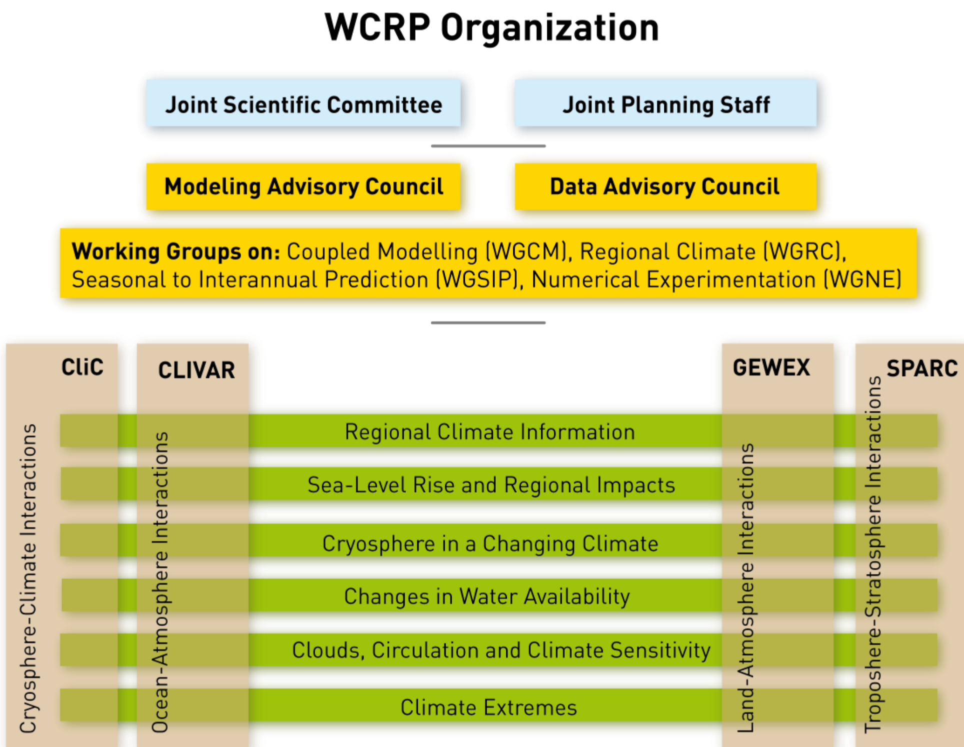
Publications applying any form of statistical downscaling to seasonal forecast products. TAO means "temporal aggregation of the output".

Reference	Country	Affiliation	Source model(s)	Approach[1]	Technique[2]	Var	Region	TAO[3]
Landman and Tennant (2000)	S. Africa	S. Africa Weather Bureau	COLA GCM	MOS-E	G-D (CCA)	P	South Africa	M
Robertson et al. (2004)	USA	Columbia University	ECHAM 4.5	MOS-D	G-S (HMM)	P	Brazil	D
Díez et al. (2005)	Spain	National Institute of Meteorology	DEMETER (2 models)	PP-E (ERA-40)	NG-D (Analogs)	P	Spain	D
Pavan et al. (2005)	Italy	ARPA-SIMC	DEMETER (6 models)	PP-E (ERA-40)	G-D (MLR)	T, P	Italy	M
Gutiérrez et al. (2005)	Spain	University of Cantabria	DEMETER (4 models)	PP-E (ERA-40)	NG-D (Analogs)	P	Northern Peru	S
Frías et al. (2005)	Spain	University of Cantabria	DEMETER (7 models)	PP-E (ERA-40, NNR)	G-D (CCA)	T	Iberian Peninsula	M
Feddersen and Andersen (2005)	Denmark	Danish Meteorological Institute	DEMETER	MOS-E	G/NG-D (SVD+WT)	P, T	Europe, N America, Australia	S
Chu et al. (2008)	Taiwan	National Taiwan Normal University	SMIP (6 GCMs)	MOS-E	G-D (SVD)	P	N Taiwan	S
Sordo et al. (2008)	Spain	University of Cantabria	ECMWF's System2	PP-E (ERA-40)	NG-D (Analogs)	P	Spain	D
Landman et al. (2009)	S. Africa	South African Weather Service	ECHAM4.5	MOS-E	G-D (CCA)	P	S Africa	S
Juneng et al. (2010)	Malaysia	Universiti Kebangsaan	APCC-MME (7 models)	MOS-E	G-D (CCA)	P	Malaysia	M
Frías et al. (2010)	Spain	University of Cantabria	DEMETER	PP-E (ERA-40)	NG-D (Analogs)	P, T	Spain	D
Min et al. (2011)	S. Korea	APEC Climate Center	APCC MME (6 models)	MOS-E	G-D (LR)	P, T	S Korea	S
Wu et al. (2012)	USA	NCAR	CFS	MOS-E	NG-D (Analogs-KNN)	P	SE Mediterranean	M
Sun and Chen (2012)	China	Institute of Atmospheric Physics	DEMETER (7 models)	MOS-E	G-D (LR)	P	Global (CRU data)	S
Kryzhov (2012)	Russia	Hydrometeorological Research Center	SLAV GCM	MOS-E	G-D (LR)	T	N Eurasia	M
Robertson et al. (2012)	USA	International Research Institute for Climate and Society	RegCM3 / ECHAM4.5	MOS-E	G-D (PC-LR)	P	Philippines	D
Ying and Ke (2012)	China	Institute of Atmospheric Physics	DEMETER (3 models)	PP-E (ERA-40)	G-D (LR)	P	SE China	S
Johnson (2012)	USA	Florida State University	DEMETER (and others)	MOS-E	G-D (LR)	P	S America	M
Tian and Martinez (2012)	USA	University of Florida	GFS / DOE	PP-E (NARR)	NG-D (Analogs)	ET_0	Florida	D
Shao and Li (2013)	Australia	CSIRO	POAMA	PP-E (NNR)	NG-D (Analogs)	P	SE Australia	D
Sinha et al. (2013)	India	Indian Institute of Technology	In-GLM1 (NCMRWF)	PP-E (NNR)	G-D (CCA)	P	India	S
de Castro et al. (2013)	Brazil	Federal University of Ceara	RSM / ECHAM4.5	MOS-E	G-D (ANN)	P	Brazil	M
Charles et al. (2013)	Australia	Bureau of Meteorology	POAMA	MOS-E	NG-D (Analogs)	P	SE Australia	D
Sohn et al. (2013)	Korea	APCC	APCC MME (10 models)	MOS-E	G-D (LR)	P	S Korea	M
Silva and Mendes (2013)	Brazil	University Federal of Rio Grande do Norte	CFS	MOS-E	G-D (ANN)	P	NE Brazil	M
Tung et al. (2013)	China	City University of Hong Kong	APCC MME	MOS-E	G-D (SVD)	P	S China	S
Pavan and Doblas-Reyes (2013)	Italy	ARPA-SIMC	ENSEMBLES (5 models)	MOS-E	G-D (MLR)	T	Italy	M

J.M. Gutiérrez (Univ. Cantabria)

WCRP Grand Challenges

- Grand Challenge on Regional Climate Information: What gaps in our scientific understanding and information, if addressed, would maximise the value content of regional climate information?
- Steering group: Clare Goodess (WGRC), Francisco Doblas-Reyes (WGSIP), Lisa Goddard (CLIVAR), Bruce Hewitson (WGRC), Jan Polcher (GEWEX & WGRC), supported by Roberta Boscolo (WCRP)



Summary

- Sub-seasonal and seasonal forecasting (s2s) are becoming well established operational activities with a solid research base and an increasing application in climate services and adaptation. Decadal prediction is moving forward quickly.
- The demand of action-relevant climate information on s2s time scales is growing. However, what forecasters provide is far from users' demand (even in the absence of skill).
- Bias correction, calibration and combination are essential in the successful application of s2s climate information.
- SPECS and EUPORIAS, along with the WWRP and WCRP initiatives (S2S, WGSIP, PPP), work together to bridge the gap and illustrate usefulness.